IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of: Anders KHULLAR et al.

For: A METHOD AND AN APPARATUS FOR ESTIMATING RESIDUAL NOISE IN A SIGNAL AND AN APPARATUS UTILIZING THE METHOD

BOX PATENT APPLICATION
Commissioner of Patents
Washington, D.C. 20231

Sir:

PATENT APPLICATION TRANSMITTAL LETTER

Transmitted herewith for filing, please find the following:

1. (XX)   The specification of the above-referenced patent application is
           enclosed herewith (_26_ page(s) including claim(s) and Abstract).

2. (XX)   ___3___ sheet(s) of:
           ___ informal drawing(s) is (are) enclosed herewith.
           _X_ formal drawing(s) is (are) enclosed herewith.

3. ( )   This application is a:
           ___ Continuation
           ___ Divisional
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       of prior copending parent application
           Serial No. _____ filed on _____, now pending.
       Please amend the application to insert the following line in the
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               --This application is a Continuation of prior
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       In the event that a petition to extend time under 37 CFR 1.136 is
       necessary in the parent application to maintain copendency for this
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4. (XX)   The fees for this application have been calculated and included as shown below (Prior to calculating the fees, please enter any enclosed preliminary amendment.):

	NO. FILED	NO. EXTRA	RATE	FEE
BASIC FEE				**$690**
TOTAL CLAIMS	25-20	5	$18	90
INDEPENDENT CLAIMS	2-3	0	$78	0
MULTIPLE DEPENDENT CLAIM(S) PRESENTED			$260	260
TOTAL FEES:				**$1040.00**
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5. (XX)   An oath or declaration is enclosed herewith that is:
   X   Unsigned
   ____   Newly executed per 37 CFR 1.63(a) and (b).
   ____   A copy of the executed declaration filed in the prior application upon which priority is based, showing the signature or an indication thereon that it was signed; and:
       ____   This application is being filed fewer than all of the inventors named in the prior application and it is requested that the following name or names be deleted from the list of inventors in the prior application for this continuation or divisional application:

_____

_____.

       ____   The prior application was accorded status under 37 CFR § 1.47 and is accompanied by:
          ____   A copy of the decision granting a petition to accord Sec. 1.47 status to the prior application (unless all of the inventors have or legal representatives have filed an oath or declaration to join in the prior application).
          ____   A copy of the subsequently executed oath(s) or declaration(s) filed by the inventor(s) or legal

representative(s) that have subsequently joined in the prior application.

6. (XX)   The power of attorney for this application:
____   is appointed in the newly executed Oath or Declaration submitted herewith.
_X_   is appointed by the power of attorney enclosed herewith.
____   remains the same as originally in the parent application.
____   was changed during the prosecution of the parent application and a copy of the change in the power of attorney is enclosed herewith.

7. (XX)   The correspondence address for this application shall be:
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_X_   which is a new correspondence address or a change therein.
____   which is the same as originally in the parent application.
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8. (XX)   Priority is hereby claimed under 35 USC 119 and 172 to the following foreign applications:

Country	Serial No.	Date
EPO	99 610 054.1	Sept. 17, 1999

and:
____   A certified copy of each application is enclosed herewith.
____   A certified copy of each application was filed in prior application Serial No. _____.

9. ( )   A verified statement claiming small entity status under 37 CFR 1.9 and 1.27:
____   is enclosed herewith.
____   was filed in parent application Serial No. _____, and such status remains unchanged and is requested for this application.

10. ( )   A preliminary amendment is enclosed herewith.

11. (XX)   An Information Disclosure Statement with Modified PTO Form 1449 and a copy of the cited references are enclosed herewith.

12. ( )   An Assignment of the invention to _____ with cover sheet and recordation fee is enclosed herewith for recordation by the Assignment Branch.

13. (XX)   The Commissioner is hereby authorized to charge payment, or to credit any overpayment, of the following fees associated with this filing or during the pendency of this application to Deposit Account No. 10-0447.
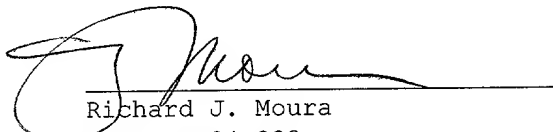_X_   Any patent application filing fees under 37 CFR 1.16.
_X_   Any patent application processing fees under 37 CFR 1.17.

___ The issue fee under 37 CFR 1.18 at or before mailing of the Notice of Allowance, pursuant to 37 CFR 1.311(b).

14. ( )   Other (specify):_____
           _____
           _____.

15. (XX)   Confirmation Postcard.

                                        Respectfully submitted,

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A method and an apparatus for estimating residual noise in a signal and an apparatus utilizing the method

5 **The Technical Field of the Invention:**

This invention relates to the estimation of residual noise in a signal. The invention may e.g. be applied for the estimation of link quality in a digital radio
10 communications system.

The invention relates specifically to: A method for estimating residual noise in the frequency range of a desired part of a signal.

15

The invention furthermore relates to: An apparatus for estimating residual noise in the frequency range of a desired part of a signal.

20 The invention moreover relates to: A mobile telephone utilizing the method.

Description of Related Art:
25

The following account of the prior art relates to one of the areas of application of the present invention, cellular digital radio communications systems.

30 Technologies for evolving cellular systems from being dominated by voice telephony to systems being capable of handling large amounts of data as well are being developed. One of the requirements of next-generation cellular systems is the ability to provide mobile access
35 to the Internet using World Wide Web (WWW) applications,

in other words to facilitate 'high speed' packet oriented data transfer.

One such so-called 3rd generation system, is the EDGE system (EDGE = Enhanced Data rates for Global TDMA Evolution, where TDMA = Time Division Multiple Access (or alternatively EDGE = Enhanced Data rates for GSM Evolution)). The EDGE system represents a convergence of the US TDMA system called TIA/EIA-136 and the European GSM system making possible the provision of wireless TDMA-based high data rate packet services for mobile users. A standard based on the EDGE concept, termed UWC-136, has been developed/approved by the European Telecommunications Standards Institute (ETSI) and by the Telecommunications Industry Association (TIA) in North America. Other 3rd generation systems, based on CDMA (Code Division Multiple Access), are likewise in the development phase: cdma2000 (specified by the (TIA)) and WCDMA (specified by ETSI). Under the name IMT-2000 (IMT = International Mobile Telecommunications) these three systems constitute the technology platforms of the International Telecommunications Union (ITU) for 3rd generation mobile communications systems.

On the air interface, GSM (and EDGE) relies on a combination of TDMA and Frequency Division Multiple Access (FDMA) in that a multitude of time slots (8 time slots = 1 TDMA frame) is mapped on a multitude of carrier frequencies (for GSM, 125).

In the first generation GSM system a data rate of 9.6 kbit/s based on circuit switching was provided using GMSK channel modulation (GMSK = Gaussian Minimum Shift Keying), each channel having a spacing between carriers of 200 kHz. The General Packet Radio Service (GPRS) for GSM constitutes an intermediate step in the development

path towards providing high speed packet mode data transfer for mobile users. GPRS provides peak user data rates between 9 kbit/s and 170 kbit/s by means of time slot concatenation (up to 8) and variable channel coding

5 (4 different). The GPRS protocol and service capabilities are reused in the EDGE system. The EDGE concept improves the data rates, among other things by means of higher level channel modulation and a higher symbol rate. Using 8-PSK modulation (PSK = Phase-Shift Keying), a symbol

10 rate of 3 bits per modulated symbol, and multislot operation, a three-fold increase in user bit rate compared to GPRS may be achieved. A data rate of e.g. 384 kbit/s may be achieved with the same 200 kHz carrier spacing and TDMA frame structure and by combining several

15 (up to 8) time slots. The improvement in data rate comes at the cost of a greater sensibility to noise, including disturbances from adjacent channels (adjacent channel interference). The maximum achievable data rate will generally depend on mobile speed and system load.

20

A digital radio receiver can be regarded as an analogue radio front-end, followed by an AD-converter. A cellular, digital radio system such as GSM or EDGE consists of several frequencies, channels, within the allocated

25 frequency band. For communication, the selected channel needs to be filtered out and it is an advantage to do this in the digital domain. Digital filters are easy to reprogram, inexpensive and do not have filter parameters varying with temperature and voltage.

30

For a GSM channel using GMSK modulation it is OK to filter hard (i.e. e.g. to use a filter with a slightly narrower bandwidth than the 200 kHz carrier spacing of a GSM channel). This is, however, not the case for a

35 corresponding EDGE channel using 8-PSK modulation and an EDGE receiver will consequently have more problems with

adjacent channel interference compared to an ordinary GSM receiver. This type of modulation will also be more sensitive to noise than for example GMSK. Thus: A compromise must be made between the wish to have a

5 broadbanded filter to include all information and the wish to avoid noise from adjacent channels.

Consequently, a system such as EDGE will depend on an LQC system (LQC = Link Quality Control) to optimise system

10 throughput.

The Quality of Service (QoS) of a digital wireless communications system may be largely related to three areas, namely call handling quality, communication

15 quality and coverage quality. The present invention, when used in a cellular communications system, is primarily related to communication quality, i.e. to such effects as radio channel impairment, transmission delay, echo, background noise, etc. For data transmission, the

20 communication quality may be quantified based on bit error rate and transmission delay. For packet oriented data transmission, bit error rate can be kept low by means of retransmission, resulting, however, in increasing delay and decreasing throughput. To optimize

25 channel throughput, it is therefore of great importance to be able to (dynamically) evaluate the channel quality, and, based hereon, to adjust the essential transmission parameters to the quality of the radio channel.

30 The measurement and reporting of the current link quality are thus most critical tasks that need to be carefully addressed. A report of the presence of a strong interferer would impact the data transmission rate, the amount of error correction overhead, or ultimately result

35 in the choice of a more robust modulation or coding scheme (e.g. from 8-PSK to GMSK channel modulation).

Summary:

It is an object of the present invention to generate a measure for the residual noise in a signal.

5

This is achieved according to the invention in that the amplitude of the signal comprising the noise is modified, and the signal is combined with the modified signal to create a noise estimation measure, as disclosed in claim
10 1.

In the present context the term 'noise' is taken to mean random noise as well as disturbances from other sources. When referred to the application of the invention in a
15 cellular communications system, the term 'noise' includes disturbances from adjacent channels (adjacent channel interference) or from channels using the same channel frequency as the 'selected' or 'desired' one in another cell (co-channel interference).
20

The residual noise estimate is based on the assumption that the amount of signal components present in the frequency ranges outside that of the desired frequency range (e.g. that of the selected channel of a cellular
25 communications system) is a measure for the amount of 'noise' present inside the desired frequency range. The usefulness of the resulting noise measure will in general depend on the structure of the signal. For signals representing the potentially overlapping channels of a
30 communications system and the like, where disturbances from 'adjacent channels' are of major concern, the measure is obtained in a simple way and very useful as an indicator of channel quality.

35 When, as disclosed in claim 2, the noise estimation measure is based on the average power content of the

signal and the modified signal over their frequency spectra, it is ensured that a simple measure for comparing the signals based on well known measurement techniques is provided. Alternatively, the noise
5   estimation measure could be based on the gradient of average power (i.e. the changes over time) of the signals in question or on any other appropriate method.

When, as disclosed in claim 3, the noise estimation
10 measure is based on the average power content of the signal and the modified signal over one or more common ranges of their frequency spectra, it is ensured that a simple measure for comparing the signals is provided, and that the measurement may be concentrated to a relevant
15 part of the frequency range, e.g. the frequency range outside the desired part of the signal.

When, as disclosed in claim 4, the signal is attenuated primarily outside the frequency range of the desired part
20 of the signal, it is ensured that the modification of the signal outside the desired frequency range may be performed in a simple way e.g. by using a filter. The attenuation may e.g. be achieved by means of a bandpass filter that passes the desired frequency range (ideally)
25 unchanged and attenuates all other frequencies. Or, alternatively, it may consist of a low-pass filter, if the desired frequency range is located from a certain frequency and downwards, or of a high-pass filter, if the desired frequency range is located from a certain
30 frequency and upwards. The modification may, however, alternatively take any other appropriate form. It may e.g. consist of an amplification of the signal outside the desired frequency range e.g. by means of one or more frequency selective amplifiers tuned to the relevant
35 frequencies.

When, as disclosed in claim 5, the noise estimation measure is based on the difference in average power content between the signal and the modified signal, it is ensured that a simple method for comparing the signals is
5 provided.

When, as disclosed in claim 6, the signal is a digital signal, it is ensured that the measure and the following processing are more stable over time and against
10 environmental influences, which further promises better performance and lower equipment production costs than corresponding functionality implemented in traditional analogue techniques.

15 When, as disclosed in claim 7, the signal is attenuated primarily outside the frequency range of the desired part of the signal by means of a digital filter, it is ensured that a cost-effective and flexible solution that is readily adapted to changes is achieved.
20

When, as disclosed in claim 8, the noise estimation measure is quantized in a number of different levels each indicating different levels of noise present, it is ensured that the measure may be used to quantify the
25 amount of undesired noise in the signal.

When, as disclosed in claim 9, the desired part of the signal represents a selected channel of a digital cellular radio system, and the noise estimation measure
30 or a postprocessed version thereof is communicated to a link quality control system of said digital cellular radio system as an estimator of current link quality, it is ensured that a simple measure for the current link quality is provided and fed back to the transmission
35 system. Other advantages of the present invention are that the implementation is potentially low-cost and that

a link quality estimate is provided at an 'early stage' of the signal path, i.e. before the signal is demodulated and further processed in the digital demodulator. This allows a fast response to changing transmission conditions allowing a dynamic adaptation of system throughput to current link quality.

When, as disclosed in claim 10, a noise estimation measurement is performed during each of the basic time units (i.e. time slot or burst) of a channel of the digital cellular radio system, and the result is communicated to a link quality control system of the digital cellular radio system as an estimator of current link quality, it is ensured that the link quality may be continuously monitored and corresponding system actions may be taken instantaneously.

When, as disclosed in claim 11, several noise estimation measurements are performed, the results are stored, and the results are evaluated, and a derived trend is communicated to a link quality control system of a digital cellular radio system as an estimator of current link quality, it is ensured that a trend in the link quality may be derived and reported.

When, as disclosed in claim 12, the noise estimation measure transferred to the link quality control system is used by the digital cellular radio system to optimize user information channel throughput by adjusting the data transmission rate, the error correction depth and/or the type of modulation, it is ensured that an optimal user throughput considering the current link quality may be achieved.

When, as disclosed in claim 13, the noise estimation measure is transferred to the digital demodulator and

used to adjust the receiver algorithm, it is ensured that an optimization of receiver processing and thus power consumption may be achieved.

5   An apparatus for estimating residual noise in the frequency range of a desired part of a signal is furthermore provided by the present invention. When, as disclosed in claim 14, it includes means for modifying the amplitude of the signal comprising the noise, and

10   means for combining the signal with the modified signal to create a noise estimation measure, and means for transferring the measure to a processing unit, it is ensured that a simple measure for the residual noise in a signal is provided.

15

When, as disclosed in claim 15, the means for combining the signal with the modified signal to create a noise estimation measure comprise a power meter for measuring average power content of the signal and the modified

20   signal over one or more common ranges of their frequency spectra, it is ensured that a simple measure for comparing the signals is provided and that the measurement may be concentrated to a relevant part of the frequency range, e.g. the frequency range outside the

25   desired part of the signal

When, as disclosed in claim 16, the means for modifying the amplitude of the signal comprising the noise include means for attenuating the signal primarily outside the

30   frequency range of the desired part of the signal, it is ensured that the modification of the signal outside the desired frequency range may be performed in a simple way, e.g. by using a filter.

35   When, as disclosed in claim 17, the means for combining the signal with the modified signal to create a noise

estimation measure comprise means for computing the difference in average power content between the signal and the modified signal, it is ensured that a simple way of providing the noise estimation measure is achieved.

When, as disclosed in claim 18, it is adapted to handle digital signals, it is ensured that the measure and the following processing steps are more stable over time and against environmental influences, which further promises better performance and lower equipment production costs than corresponding functionality implemented in traditional analogue techniques.

When, as disclosed in claim 19, the means for attenuating the signal primarily outside the frequency range of the desired part of the signal comprise a digital filter, it is ensured that a cost-effective and flexible solution that is readily adapted to changes is achieved.

When, as disclosed in claim 20, it includes means for storing consecutive values of the noise estimation measure, and means for processing the values to extract a trend, and means for communicating the individual values or the extracted trend or postprocessed versions hereof to a quality control system, it is ensured that an appropriate postprocessing of the noise estimation measure may be performed readily. The processing means may e.g. include means for quantizing the noise estimation measure in a number of different levels, i.e. to grade a given measurement value on an appropriate scale according to the expected dynamic range of the values.

A mobile telephone is moreover provided by the present invention. When, as disclosed in claim 21, it contains an apparatus, comprising means for performing the steps of

claim 1, for estimating residual noise in the frequency range of a desired part of a signal, and means for storing, evaluating and transmitting resulting noise estimation measurements or postprocessed versions thereof

5 to a link quality control system of a cellular radio system, it is ensured that the cellular radio system is provided with a link quality estimate that may be used to optimize the user throughput.

10 When, as disclosed in claim 22, it is adapted to perform the noise estimation measurement during each of the basic time units (i.e. time slot or burst) of a channel of the digital cellular radio system, it is ensured that the link quality may be monitored continuously and

15 corresponding system actions may be taken instantaneously.

Brief Description of the Drawings:

20

The invention will be explained more fully below in connection with a preferred embodiment and with reference to the drawings in which:

25 fig. 1 shows the front-end of a receiver for a mobile telephone of a cellular digital radio communications system according to the invention,

fig. 2 shows an idealized sketch of the frequency

30 dependence of the received power of the signal before and after the digital filter, and

fig. 3 shows a part of a front-end of a receiver for a mobile telephone of a cellular digital radio

35 communications system according to the invention.

Detailed Description of Embodiments:

Fig. 1 shows the front-end of a receiver for a mobile
telephone of a cellular digital radio communications
system according to the invention.

In fig. 1, 101 denotes the receiver antenna (optionally
used together with the transmitter part via a duplexer),
and 110 denotes the received radio frequency signal. The
received signal 101 is fed to an RX-band filter 102 that
filters out the relevant received frequency band,
delivering the signal 111 containing the frequency band
allocated to the cellular system in question, e.g. the
GSM frequency band around 900 MHz or the IMT-2000
frequency band allocated around 1950 MHz. The signal 111
is fed to an analogue demodulator 103 that mixes the
relevant part of the frequency band down in the baseband,
using a system-given channel frequency 109 for the down-
conversion. The output signal 112 from the analogue
demodulator 103 is fed to an analogue filter 104 that
filters out the frequencies around the relevant channel,
resulting in the signal 113. The signal 113 contains
noise and disturbances from adjacent channels. An AD-
converter 105 (AD = Analogue to Digital) converts the
signal 113 to the digital domain in the form of the
signal 114. A digital filter 108 filters out the relevant
channel 115 from the input signal 114. Using the digital
signals before and after the digital filter 108, i.e.
signals 114 and 115 as inputs, the Link Quality Estimator
106 measures the difference in average power content
between the two input signals and outputs a signal 116 to
the signal processing unit 107. The measure 116
represents an indicator of residual noise in the
frequency range of the desired signal 115.

The measure 116 may be further processed by the signal processing unit 107. As a result, a message 117 representing the current link quality (or a trend herein) is forwarded to the transmission part 118 of the mobile
5   unit and transmitted to the Link Quality Control system of the digital radio communications system, i.e. to the base station presently allocated to the mobile telephone.

Fig. 2 shows an idealized sketch of the frequency
10   dependence of the received power of the signal before and after the digital filter. The frequency axis is denoted by 260. Although the relevant signals 114 and 115 of fig. 1 are digital, a frequency dependence of the power content corresponding to their analogue representations
15   is shown for illustrative purposes.

The input signal to the digital filter 114 of fig. 1 is schematically depicted in fig. 2.a. The signal contains noise (not indicated) and signal components 230, 250 from
20   adjacent channels, whose signal power is primarily located in the frequency ranges 270 and 272, in addition to the desired signal components 240 of the selected channel 271, i.e. there is undesired amplitude at frequencies outside as well as inside the frequency range
25   of the desired/selected channel 271. The sketch represents a situation with a strongly disturbing neighbouring signal 230 and a moderately disturbing neighbouring signal 250. The grey shaded areas in fig. 2.a represent the frequency ranges where an overlap with
30   the adjacent channels is present. After (non-ideal) filtering of the signal 114 of fig. 1, the resulting signal 115 of fig. 1 primarily has signal amplitude 241 in the frequency range 271 of the desired signal, as schematically illustrated in fig. 2.b (where the signal
35   amplitudes outside the range 271 (mainly components 231 and 251) are somewhat exaggerated for illustrative

purposes). However, a part of the amplitude of the signal in the desired frequency range 271 originates from noise and/or adjacent channels, as indicated by the shaded area 280. By measuring the average power of signal 115 of fig.

5   1 and subtracting it from the average power of signal 114 of fig. 1 (both taken over the entire frequency range of signal 114) we get a measure for the 'noise' (i.e. undesired signal components) in the desired frequency range 271. This is illustrated in fig. 2.c, where the sum

10 of the shaded areas 232 and 252 represents the measure. I.e. we assume that the amount of signal components present in the frequency ranges 270, 272 outside that of the selected channel is a measure for the amount of 'noise' (i.e. primarily undesired signal components from

15 adjacent channels) present inside the frequency range 271 of the selected channel. The usefulness of the resulting noise measure will in general depend on the structure of the signal 114. For signals representing the potentially overlapping channels of a communications system and the

20 like, the measure is certainly very useful.

After filtering, the received signal consists of the signal from the selected channel and additional noise from adjacent channels, not removed by the non-ideal

25 filters (cf. fig. 2.b). The relation in strength between the selected channel and adjacent channels will determine the amount of residual adjacent channel noise. This relation will influence the receiver performance.

30 An estimation of the adjacent channel residual noise will therefore also be useful in the following digital signal processing (block 107 of fig. 1). Receiver algorithms may be tailored to match the interference presence in each single burst.

35

The measurements of the average power of the signals 114 and 115 of fig. 1 are performed over the frequency range where the signal 114 has a significant amplitude, i.e. ranges 270, 271 and 272 in fig. 2. In a special
5 embodiment of the invention, the frequency range of measurement is restricted to that outside the selected channel (i.e. to the ranges 270, 272). This has the advantage of eliminating the attenuation of the filter in the desired frequency range 271 from the measurement.
10

The output signal 116 of fig. 1 is quantized in the Link Quality Estimator block 106 and takes on one of a relevant number of levels, e.g. 8, in which the range of the possible results is subdivided. The 'scale' of the
15 levels may be linear or logarithmic dependent on the dynamic range of the measurement results. The interpretation of the measurements is as follows: A relatively large absolute difference in average power content represents a relatively large residual noise and
20 hence a relatively low link quality estimate, whereas a relatively small absolute difference in average power content represents a relatively small residual noise and hence a relatively high link quality estimate. This may be illustrated by fig. 2.c, where the shaded area 232,
25 taken alone, represents a relatively large absolute difference in average power content corresponding to a relatively large amount of residual noise in the desired frequency range and correspondingly a relatively low link quality. Similarly, the shaded area 252, taken alone,
30 represents a relatively small absolute difference in average power content corresponding to a relatively small amount of residual noise in the desired frequency range and correspondingly a relatively high link quality.

35 In an alternative embodiment, a part of the evaluation of the difference in average power content between the two

input signals 114 and 115 of fig. 1 to the Link Quality Estimator 106 is performed in the control unit contained in the processing block 107 (cf. 320 in fig. 3).

5   Fig. 3 shows a part of a front-end of a receiver for a mobile telephone of a cellular digital radio communications system according to the invention.

In fig. 3, the signal processing unit 107 is subdivided 10   in control unit 320 and digital demodulator 321 blocks. The signal 115 from the digital filter 108 is fed to the digital demodulator 321 for further processing and to the control unit 320 for possible evaluation and extraction of further information concerning link quality in 15   addition to that of the noise estimation measure signal 116 from the Link Quality Estimator block 106. The control unit 320 includes a Digital Signal Processor (DSP) and memory (e.g. RAM) for the storage of the most recent noise estimation measures, and for the generation 20   of the link quality estimate 117 that is fed to the transmission part 118 of the mobile telephone for transfer to the Link Quality Control system. In a preferred embodiment of the invention, the functions of the control unit and the digital demodulator are 25   integrated in one functional block (cf. 107 of fig. 1).

One use of the residual noise measure 116 according to the invention is to adjust the link quality estimate 117 reported and used by the network for optimising system 30   throughput. This use of the invention would e.g. improve the performance of the LQC concept proposed for the EDGE system.

The digital demodulator 321 demodulates the digital 35   signal 115 and extracts the user-specific information and control information. The control unit 320 (e.g. a DSP

with internal and possibly extra accessible external memory) evaluates the control information. One part of the control information is extracted from the received signal 115 and possibly transferred from the demodulator
5   321 via the connection 319, the other is the noise estimation measure 116 transferred from the Link Quality Estimator 106. Based thereon, the control unit 320 performs the relevant actions, e.g. sends a report 117, via the transmit part 118 of the mobile telephone, to the
10 Link Quality Control system concerning the present channel quality or the trend in channel quality. The latter is based on stored values of recent channel quality data. In a preferred embodiment of the invention, the measured noise estimation values are stored and
15 evaluated in the Link Quality Estimator 106. It may alternatively be stored and evaluated in the control unit 320 of the processing unit 107. Based on a number (e.g. 100) of stored values, the trend may be derived by any one of a variety of standard methods, e.g. by simply
20 taking the average value, or by computing the slope of a straight line fitted to the stored measurements (time, value) and evaluating it together with the most recent measurement value, etc.

25 The link quality estimation data may e.g. be transmitted from the mobile station to its presently allocated base station and hence to the LQC system via one of the logic control channels of the system that carries signalling or synchronization data (as opposed to traffic channels that
30 carry the user speech or data), as symbolized by the signal 117 to the transmit part 118 of the mobile station. In a GSM system, the logic control channels are e.g. termed BCCH (Broadcast Control Channel), CCCH (Common Control Channel), SDCCH (Stand-alone Control
35 Channel), ACCH (Associated Control Channel), the latter having a Slow (SACCH) and Fast (FACCH) version. The SACCH

and FACCH may both be used to transfer signalling data, including e.g. a link quality estimate, during a connection.

5   The basic unit of a logic control channel in the GSM and EDGE systems is 184 bits long. To ensure protection against transmission errors, the 184 control bits are mapped onto a 456 bit block by adding check bits and a channel code to provide error correction possibilities.

10   The contents of the logical channels are mapped onto and transferred via physical channels. The 456 bit blocks are partitioned in subblocks of 57 bits length, which are interleaved with subblocks of neighbouring 456 bit blocks and mapped onto logical 'bursts' each of 114 bits length.

15   By the addition of extra bits for administrative purposes (tail bits and guard period), the logical bursts are mapped onto the physical bursts each of 156.25 bits length (or 577 μs) for the actual transmission. This is the basic time slot unit for a GSM or EDGE based system

20   onto which all normal and control information is to be mapped.

A physical channel in a TDMA system is defined as a time slot with a time slot number in a sequence of TDMA

25   frames. To protect against fading, frequency hopping may be applied. This means that the physical channel is partitioned in both time and frequency so that each burst is transmitted via a different radio frequency (RF) channel. The physical channel is thus defined as a

30   sequence of RF channels and time slots. Each carrier frequency supports eight physical channels mapped onto eight time slots within a TDMA frame.

Details of the GSM logical traffic and control channels

35   and their mapping onto physical channels are standardized

in GSM Recommendation R.05 dealing with the 'Physical layer on the radio path'.

The quality measurements (i.e. the noise detection estimate and its further processing) may be performed in each burst or with a certain frequency, e.g. every TDMA frame (= 8 time slots) or every multiframe (= 26 TDMA frames in a GSM system), etc. Alternatively, the measurement frequency may be made dependent on the measurement results following a predefined algorithm (e.g. relatively high quality measures being associated with relatively low measurement frequencies, the measurement frequencies being confined to a certain min-max-range). Similar patterns may be employed for the reporting of the measure to the Link Quality Control system. The link quality measure may be reported via one of the signalling channels of the cellular communications system. Referring to the GSM system: If a relatively slow frequency of reporting is needed (e.g. in reporting trends) the SACCH signal may e.g. be used (1 SACCH is sent per multiframe, each consisting of 26 TDMA frames, i.e. every 120 ms). If an 'instant' reporting is needed (e.g. when reporting per burst) the FACCH signal may be used. The FACCH is inserted instead of user data using a so-called 'stealing flag' to distinguish signalling data from user data within a burst.

In a preferred embodiment of the invention, the report of the current link quality estimates or the trend therein to the Link Quality Control system, is used by the system to decide whether to change parameters concerning the link throughput such as data transmission rate, 'error correction depth' and/or type of modulation (e.g. between 8-PSK and GMSK). This decision may be based on other parameters possibly reported by the mobile station as well, e.g. the received level of the channel carrier, the

absolute distance between the base and mobile stations, the bit error ratio before channel decoding, etc.

Another use of the information represented by the
5 residual noise measure is to introduce ways to compensate each burst by signal processing. Each burst will have an estimation of the interference. This information may be used for:

10 * Fast adaptation of for example receiver filtering properties.
* Input data to noise cancellation algorithms.

In a preferred embodiment of the invention, the
15 measurements are performed in each burst and the results are currently reported to the signal processing unit via the connection 319 in fig. 3 and used therein to modify the receiver algorithm to improve receiver performance, e.g. by adjusting the amount of 'data processing' (error
20 correction, etc.) controlled by the link quality estimate. This will enable the use of algorithms, designed to optimize performance at different reception conditions. If e.g. the link quality is good, less complex receiver algorithms may be employed and thus
25 power may be saved. The latter is of particular importance in mobile units such as cellular telephones.

Although the invention has been described in relation to
30 a digital cellular radio communications system using TDMA, it may also be used in all other situations where a measure for the residual noise in a signal is needed, e.g. in other communications systems, be it CDMA based systems, frequency hopping or non frequency hopping
35 systems, analogue systems, etc.

Claims:

1. A method for estimating residual noise in the
frequency range (271) of a desired part (240) of a
signal,
c h a r a c t e r i z e d in that
the amplitude of the signal (114) comprising the noise is
modified, and the signal (114) is combined with the
modified signal (115) to create a noise estimation
measure (116).

2. A method according to claim 1,
c h a r a c t e r i z e d in that
the noise estimation measure (116) is based on the
average power content of the signal (114) and the
modified signal (115) over their frequency spectra (270,
271, 272).

3. A method according to claim 2,
c h a r a c t e r i z e d in that
the noise estimation measure (116) is based on the
average power content of the signal (114) and the
modified signal (115) over one or more common ranges
(270; 271; 272) of their frequency spectra.

4. A method according to any one of claims 1 to 3,
c h a r a c t e r i z e d in that
the signal (114) is attenuated primarily outside (270,
272) the frequency range (271) of the desired part (240)
of the signal.

5. A method according to any one of claims 2 to 4,
c h a r a c t e r i z e d in that

the noise estimation measure (116) is based on the difference in average power content (232, 252) between the signal (114) and the modified signal (115).

5   6. A method according to any one of claims 1 to 5,
c h a r a c t e r i z e d   in that
the signal (114) is a digital signal.

7. A method according to any one of claims 4 to 6,
10   c h a r a c t e r i z e d   in that
the signal (114) is attenuated primarily outside (270, 272) the frequency range (271) of the desired part (240) of the signal (114) by means of a digital filter (108).

15   8. A method according to any one of claims 1 to 7,
c h a r a c t e r i z e d   in that
the noise estimation measure (116) is quantized in a number of different levels each indicating different levels of noise present.
20

9. A method according to any one of claims 1 to 8,
c h a r a c t e r i z e d   in that
the desired part (240) of the signal (114) represents a selected channel of a digital cellular radio system, and
25   the noise estimation measure (116) or a postprocessed version thereof (117) is communicated to a link quality control system of said digital cellular radio system as an estimator of current link quality.

30   10. A method according to claim 9,
c h a r a c t e r i z e d   in that
a noise estimation measurement is performed during each of the basic time units (i.e. time slot or burst) of a channel of the digital cellular radio system, and the
35   result (116; 117) is communicated to a link quality

control system of the digital cellular radio system as an estimator of current link quality.

11. A method according to any one of claim 9 or 10,
c h a r a c t e r i z e d   in that
several noise estimation measurements are performed, the results are stored, and the results are evaluated, and a derived trend is communicated to a link quality control system of a digital cellular radio system as an estimator of current link quality.

12. A method according to any one of claims 9 to 11,
c h a r a c t e r i z e d   in that
the noise estimation measure transferred to the link quality control system is used by the digital cellular radio system to optimize user information channel throughput by adjusting the data transmission rate, the error correction depth and/or the type of modulation.

13. A method according to any one of claims 9 to 12,
c h a r a c t e r i z e d   in that
the noise estimation measure is transferred to a digital demodulator (321) and used to adjust the receiver algorithm.

14. An apparatus for estimating residual noise in the frequency range of a desired part of a signal,
c h a r a c t e r i z e d   in that
it includes means (108) for modifying the amplitude of the signal (114) comprising the noise, and means (106) for combining the signal (114) with the modified signal (115) to create a noise estimation measure (116), and means (106) for transferring the measure to a processing unit (107).

15. An apparatus according to claim 14,

c h a r a c t e r i z e d in that
the means (106) for combining the signal (114) with the
modified signal (115) to create a noise estimation
measure (116) comprise a power meter for measuring
average power content of the signal (114) and the
modified signal (115) over one or more common ranges
(270; 271; 272) of their frequency spectra.

16. An apparatus according to claim 14 or 15,
c h a r a c t e r i z e d in that
the means (108) for modifying the amplitude of the signal
(114) comprising the noise include means for attenuating
the signal primarily outside (270, 272) the frequency
range (271) of the desired part (240) of the signal
(114).

17. An apparatus according to any one of claim 15 or 16,
c h a r a c t e r i z e d in that
the means (106) for combining the signal (114) with the
modified signal (115) to create a noise estimation
measure (116) comprise means for computing the difference
in average power content (232, 252) between the signal
(114) and the modified signal (115).

18. An apparatus according to any one of claims 14 to 17,
c h a r a c t e r i z e d in that
it is adapted to handle digital signals.

19. An apparatus according to claim 18,
c h a r a c t e r i z e d in that
the means (105) for attenuating the signal primarily
outside (270, 272) the frequency range (271) of the
desired part (240) of the signal comprise a digital
filter.

20. An apparatus according to any one of claims 14 to 19,

c h a r a c t e r i z e d   in that
it includes means (106; 107) for storing consecutive
values of the noise estimation measure, and means (106;
107) for processing the values to extract a trend, and
5   means (107) for communicating the individual values or
the extracted trend or postprocessed versions thereof to
a quality control system.

21. A mobile telephone,
10   c h a r a c t e r i z e d   in that
it contains an apparatus, comprising means (106, 108) for
performing the steps of claim 1, for estimating residual
noise in the frequency range (271) of a desired part
(240) of a signal (114), and means (106, 107) for
15   storing, evaluating and transmitting resulting noise
estimation measurements or postprocessed versions thereof
(116, 117) to a link quality control system of a cellular
radio system.

20   22. A mobile telephone according to claim 21,
c h a r a c t e r i z e d   in that
it is adapted to perform a noise estimation measurement
during each of the basic time units (i.e. time slot or
burst) of a channel of the digital cellular radio system.
25

A method and an apparatus for estimating residual noise
in a signal and an apparatus utilizing the method

Abstract:

The invention relates to: A method for estimating
residual noise in the frequency range (271) of a
desired part (240) of a signal to a corresponding
apparatus and to a mobile telephone utilizing the
method.
The object of the present invention is to generate a
measure for the residual noise in a signal.
The problem is solved in that the amplitude of the
signal (114) comprising the noise is modified, and the
signal (114) is combined with the modified signal (115)
to create a noise estimation measure (116).
The invention may e.g. be used in digital radio
communications systems to contribute to the monitoring
of link quality and therefore to improve payload
throughput. One of the advantages of the invention is
that an indication of link quality at an early stage in
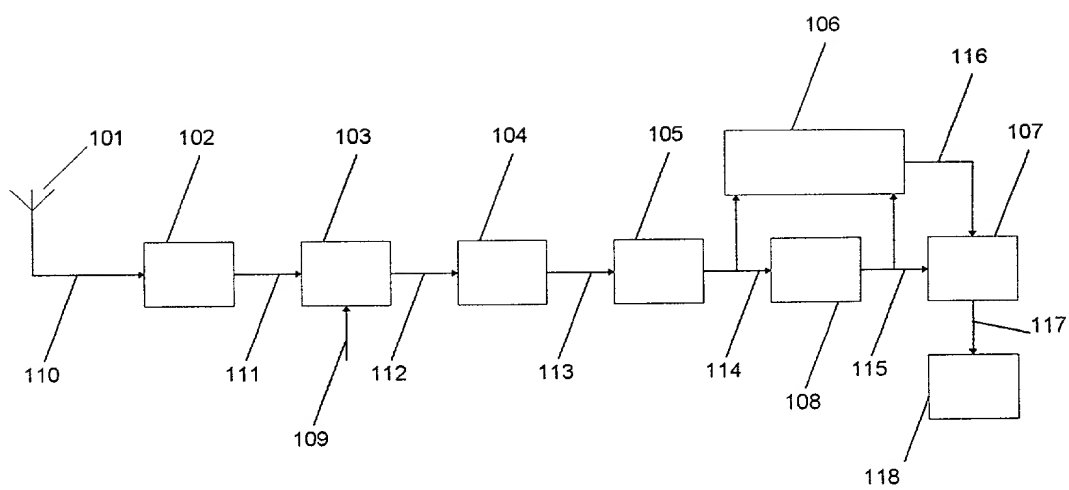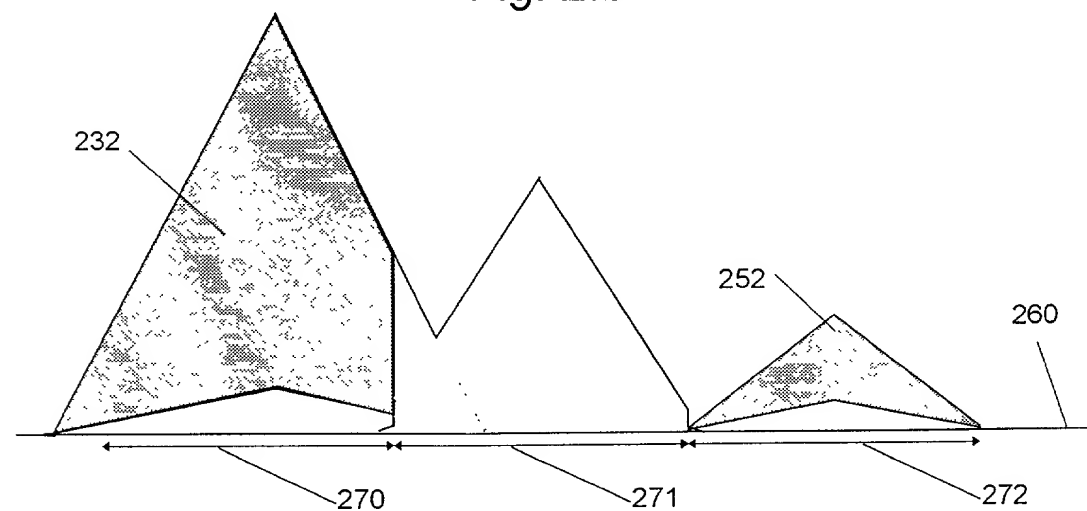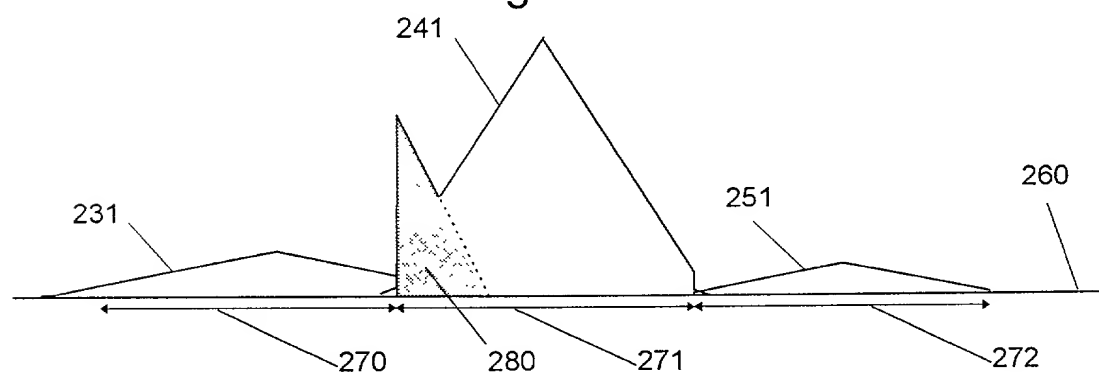the receiver is provided.

(Figs. 2.a, 2.b, 2.c should be published)

Fig. 1

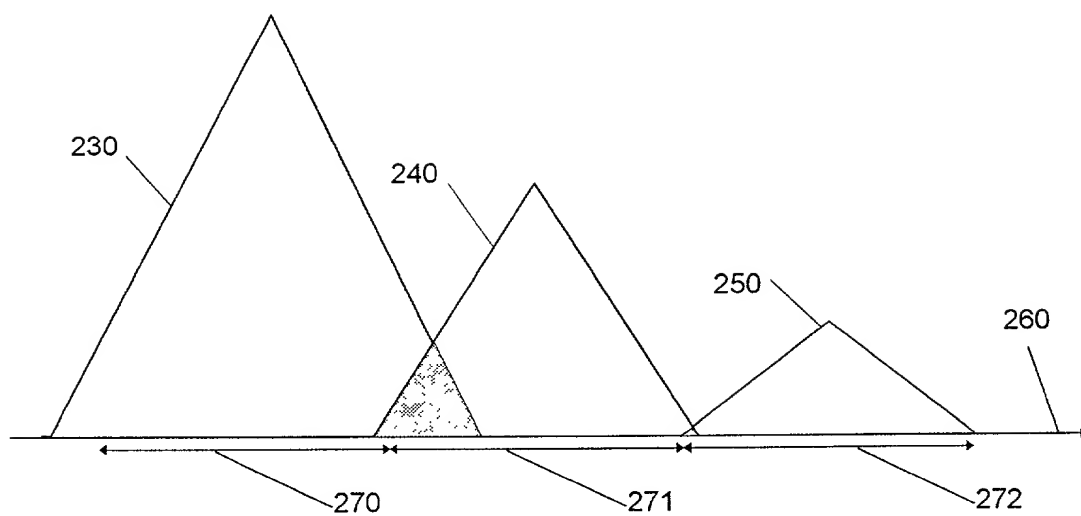Fig. 2.a

Fig. 2.b

Fig. 2.c
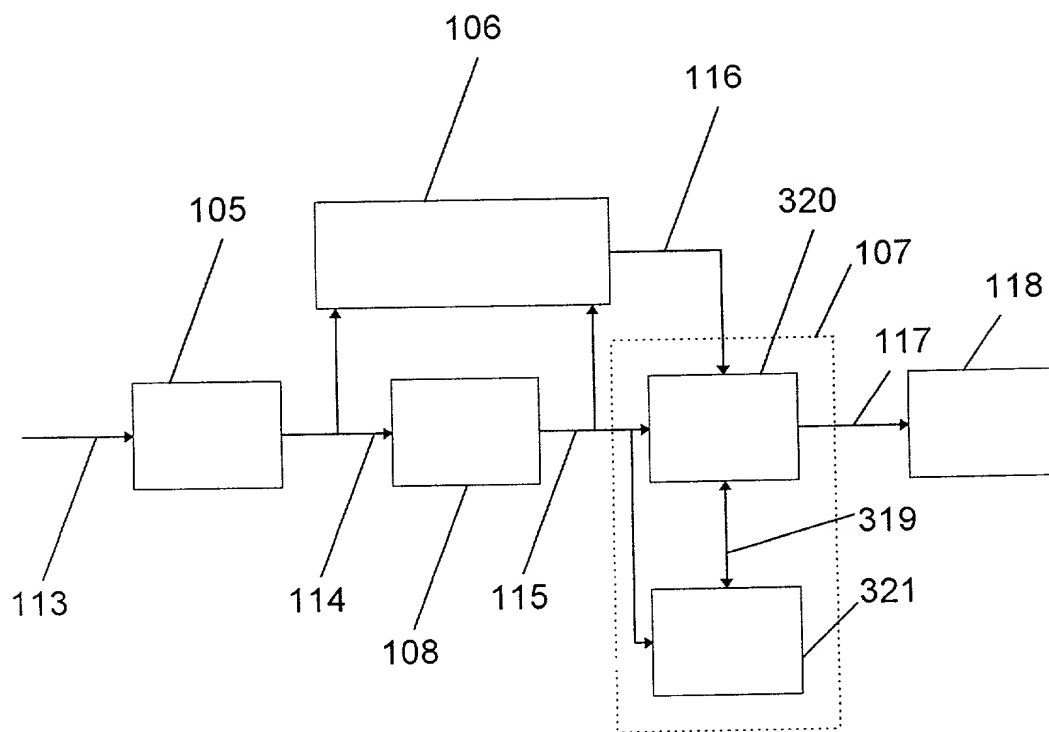
Fig. 3

RULES 63 AND 67 (37 C.F.R. 1.63 and 1.67)
DECLARATION AND POWER OF ATTORNEY

FOR UTILITY/DESIGN/CIP/PCT NATIONAL APPLICATIONS

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name; and

I believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: **A METHOD AND AN APPARATUS FOR ESTIMATING RESIDUAL NOISE IN A SIGNAL AND AN APPARATUS UTILIZING THE METHOD**, the specification of which: (mark only one)

<u>X</u>	(a)	is attached hereto.
_	(b)	was filed on <u>herewith</u> as Application Serial No. <u>not assigned</u> and was amended on _____ (if applicable)
_	(c)	was filed as PCT International Application No. PCT/_____ on ____ and was amended on _____ (if applicable).
_	(d)	was filed on __ as Application Serial No. __ and was issued a Notice of Allowance on ___.
_	(e)	was filed on __ and bearing attorney docket number <u>47253-12</u>

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above or as allowed as indicated above.

I acknowledge the duty to disclose all information known to me to be material to the patentability of this application as defined in 37 CFR § 1.56. If this is a continuation-in-part (CIP) application, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose to the Office all information known to me to be material to patentability of the application as defined in 37 CFR § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

I hereby claim foreign priority benefits under 35 U.S.C. § 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate filed by me or my assignee disclosing the subject matter claimed in this application and having a filing date (1) before that of the application on which my priority is claimed or, (2) if no priority is claimed, before the filing date of this application:

PRIOR FOREIGN PATENTS

Number	Country	Month/Day/Year Filed	Date first laid-open or Published	Date patented or Granted	Prioity Claimed Yes	No
99 610 054.1	EPO	Sept. 17. 1999			XX	

I hereby claim the benefit under 35 U.S.C. § 120/365 of any United States application(s) listed below and PCT international applications listed above or below:

PRIOR U.S. OR PCT APPLICATIONS

Application No. (series code/serial no.)	Month/Day/Year Filed	Status(pending, abandoned, patented)

none

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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